

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
19 September 2002 (19.09.2002)

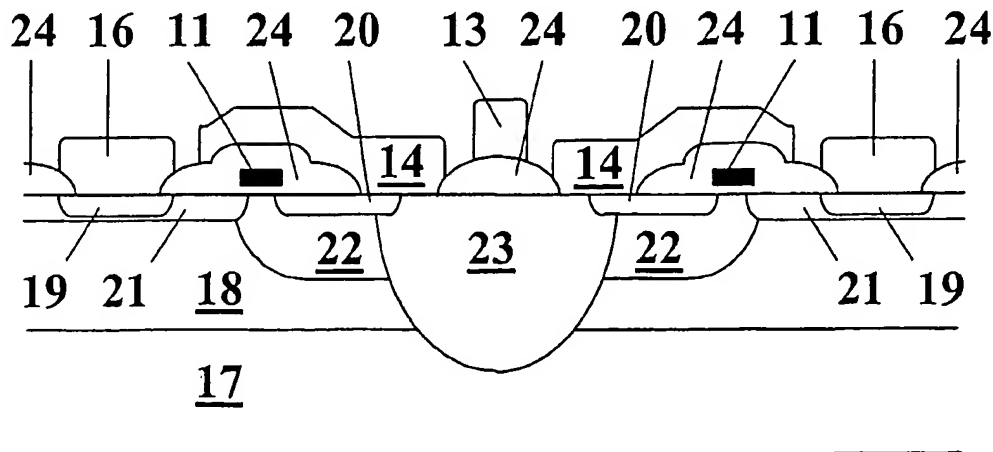
PCT

(10) International Publication Number  
**WO 02/073701 A1**

- (51) International Patent Classification<sup>7</sup>: H01L 29/78, 23/528
- (21) International Application Number: PCT/SE02/00414
- (22) International Filing Date: 7 March 2002 (07.03.2002)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
0100804-4 9 March 2001 (09.03.2001) SE
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- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:  
— with international search report

[Continued on next page]

(54) Title: AN RF POWER LDMOS TRANSISTOR



(57) Abstract: In an RF power LDMOS transistor comprising multiple pairs of parallel gate fingers (11) located on opposite sides of an associated p<sup>+</sup> sinker (23), and metal clamps (14) for short-circuiting the p<sup>+</sup> sinkers (23), each gate finger (11) of a pair is associated with separate metal clamps (14) that short-circuit the n<sup>+</sup> source region (20) and the p<sup>+</sup> sinker (23) associated with particular gate finger (11). The separate metal clamps (14) associated with each gate finger pairs are separated by a slot (15) that extends between the parallel gate fingers (11), and a metal runner (13) extends in the slot (15) between the separate metal clamps (14) associated with each finger pair from a gate pad. Both gate fingers (11) of a gate finger pair are connected to the associated metal runner (13) at both ends and at predetermined positions along their lengths.



*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## **AN RF POWER LDMOS TRANSISTOR**

### **TECHNICAL FIELD**

The invention relates generally to RF power LDMOS transistors and more specifically to such transistors for use in third generation wireless communication systems.

### **BACKGROUND OF THE INVENTION**

Discrete RF power LDMOS transistors are primarily used for building power amplifiers used in radio base stations.

A top view of a portion of the layout of a traditional RF power LDMOS transistor is illustrated in Fig. 1. The transistor comprises a number of parallel LDMOS transistor cells, two of which are shown in Fig. 1, where the cells are an interdigitated finger structure containing pairs of drain fingers 1, pairs of gate fingers 2 and source/bulk metal clamps 3. The drain fingers 1 and the gate fingers 2 are connected to a drain feeder bar 4 and a gate feeder bar 5, respectively, on opposite sides of the transistor cells as shown in Fig. 1. Traditional LDMOS Power transistors comprise a number of parallel cells.

However, third generation (3G) wireless systems set new demands on RF power transistors. Not only higher frequency (>2 GHz), which in itself is a challenge, but extreme demands on linearity has compelled designers of power amplifiers to use power transistors way below their rated maximum output power. It is at this backed off output power level the transistors must perform, i.e. have high gain and good efficiency.

These new demands have forced RF power transistor designers to leave the old "parallel cells" layout of the transistors and switch to a slightly different design. The 3G design uses only one interdigitated transistor cell, rotated 90 degrees compared to the orientation of the cells in the older design.

The largest benefit with this new design is a considerably reduced transistor periphery per active transistor area, which in turn results in lower output capacitance and improved efficiency.

In order to make the gate periphery equal to a transistor with multiple parallel cells, the single cell needs to be stretched in both dimensions, so that it contains many more fingers. In order to keep a decent aspect ratio of the transistor die, the fingers also need to be much longer.

The principle for the 3G design is shown in Fig. 2 which is a top view of a portion of the layout of a known 3G RF power LDMOS transistor. Pairs of drain fingers 6, of which only one pair is shown in Fig. 2, are connected to a common drain bond pad (not shown). Pairs of gate fingers 7, of which only one pair is shown in Fig. 2, are interconnected at their ends and at predetermined positions along their lengths by pieces of a first metal layer. One such interconnection piece 8 is shown in Fig. 2. Source/bulk metal clamps 9, also produced from said first metal layer, extend over the pair of gate fingers 7 between the interconnection pieces.

As described above, the 3G design is unavoidably associated with longer fingers. This is a problem especially on the gate side of the transistor. The gate fingers are usually made of highly doped polysilicon, possibly with a layer of metal silicide on top, in order to reduce the resistivity. However, the resistance in the gate fingers is far from negligible, and at some point the length of the gate fingers will affect transistor performance negatively.

The way this problem has been solved in the known 3G design of the transistor is by introducing a second metal layer. By doing this, one can design a metal runner 10 on top of the source/bulk clamps 9. The metal runner 10 is isolated from the clamps 9 by a dielectric layer (not shown in Fig. 2), and is connected to the pair of gate fingers 7 at predetermined positions along the length of gate fingers 7 via the interconnection piece 8

as well as at their respective ends. One end of the metal runners 10 is connected to a common gate bond pad (not shown).

Hereby, the effective length of each gate finger will be equal to half the distance between two gate interconnection pieces.

However, the introduction of the second metal layer in the transistor design adds complexity both to the design and to the production process. In this connection, it should be pointed out that in Fig. 2, the drain fingers 6 are made up of two metal layers, namely the second metal layer on top of the first metal layer. Two extra mask steps together with a number of extra process steps need to be added to the production process of the transistor die.

### **SUMMARY OF THE INVENTION**

The object of the invention is to bring about a 3G RF power LDMOS transistor that is less complex to produce than those known so far.

This is attained by means of the transistor according to the invention mainly by using only one metal layer with intermediate contact to the long gate fingers.

### **BRIEF DESCRIPTION OF THE DRAWING**

The invention will be described more in detail below with reference to the appended drawing on which Fig. 1 described above shows the layout of a traditional RF power LDMOS transistor, Fig. 2 described above shows the layout of a known 3G RF power LDMOS transistor, Fig. 3 shows the layout of a 3G RF power LDMOS transistor according to the invention, and Fig. 4 is a cross-sectional view of the transistor according to the invention in Fig. 3 along line A - A.

### **DESCRIPTION OF THE INVENTION**

Fig. 3 shows the layout of a 3G RF power LDMOS transistor according to the invention.

Contrary to the known 3G transistor in Fig. 2, that comprises two metal layers, the 3G transistor according to the invention comprises only one metal layer.

In the transistor according to the invention in Fig. 3, gate fingers 11 of each pair of gate fingers are interconnected at their ends and at predetermined positions along their lengths by pieces of a metal layer. One such interconnection piece 12 is shown in Fig. 3.

In accordance with the invention, a metal runner 13 that is connected to a common gate bond pad (not shown), is produced for each pair of gate fingers 11 in one piece with the interconnection pieces 12 for the respective pair of gate fingers.

Also in accordance with the invention, separate source/bulk metal clamps 14, produced from the same metal layer as the interconnection pieces 12 and the metal runners 13, are associated with each gate finger 11 of each pair of gate fingers. The metal clamps 14 associated with the respective gate finger 11 of a pair of gate fingers, are separated by a slot 15 that extends between the parallel gate fingers 11 of each gate finger pair.

In accordance with the invention, the metal runners 13 are produced in the slots 15 between the metal clamps 14.

Pairs of drain fingers 16, produced from the same metal layer as the interconnection pieces 12, the metal runners 13, and the metal clamps 14, are connected to a common drain bond pad (not shown) in the transistor.

Fig. 4 is a cross-sectional view of the transistor according to the invention along the line A - A in Fig. 3. In Fig. 4, the same reference numerals as in Fig. 3 are used to denote identical elements.

In a manner known per se, the transistor is built into a p<sup>+</sup> substrate 17 with a p-epi 18 on top, and consists of alternating n<sup>+</sup> drain regions 19 and n<sup>+</sup> source regions 20 where the n<sup>+</sup> drain region 19 is separated from the gate 11 by an n- drift region 21.

A p-type channel dopant or p-well 22 is diffused laterally in under the gate 11 from its source side.

A deep p+ diffusion or p+ sinker 23 enables current to be passed on from the n+ source region 20 to the p+ substrate 17 with minimal voltage drop by means of the metal clamp 14 shorting these regions to one another.

A dielectric layer 24 separates the gate fingers 11 from the metal clamps 14 and the metal runners 13 from the p+ sinker regions 23.

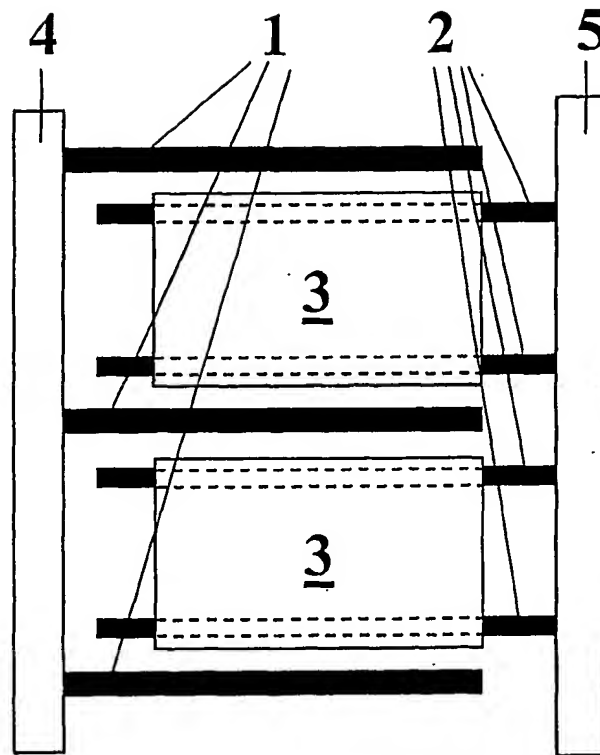
## CLAIMS

1. An RF power LDMOS transistor comprising multiple pairs of parallel gate fingers (11), the gate fingers (11) of each gate finger pair being located on opposite sides of an associated  $p^+$  sinker (23), and metal clamps (14) being provided to short-circuit the  $p^+$  sinkers (23) and  $n^+$  source regions (20) on opposite sides of the  $p^+$  sinkers (23),

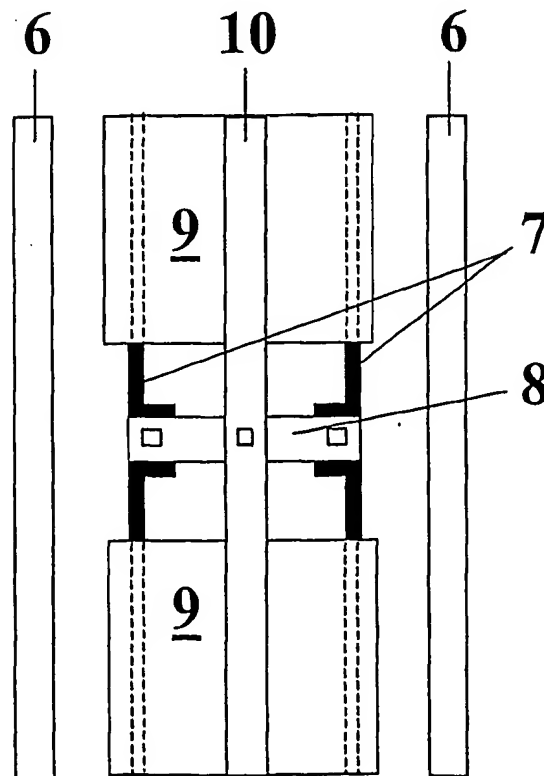
**characterized in**

- that each gate finger (11) of a gate finger pair is associated with separate metal clamps (14) that short-circuit the  $n^+$  source region (20) and the  $p^+$  sinker (23) associated with that particular gate finger (11),
- that the separate metal clamps (14) associated with each gate finger pair are separated by a slot (15) that extends between the parallel gate fingers (11),
- that a metal runner (13) extends in the slot (15) between the separate metal clamps (14) associated with each gate finger pair from a gate pad, and
- that both gate fingers (11) of a gate finger pair are connected to the associated metal runner (13) at both their ends and at predetermined positions along their lengths.

2. The transistor according to claim 1, **characterized in** that the metal runners (13) are provided on a dielectric layer (24) on top of the  $p^+$  sinkers (23).



**Fig. 1**



**Fig. 2**

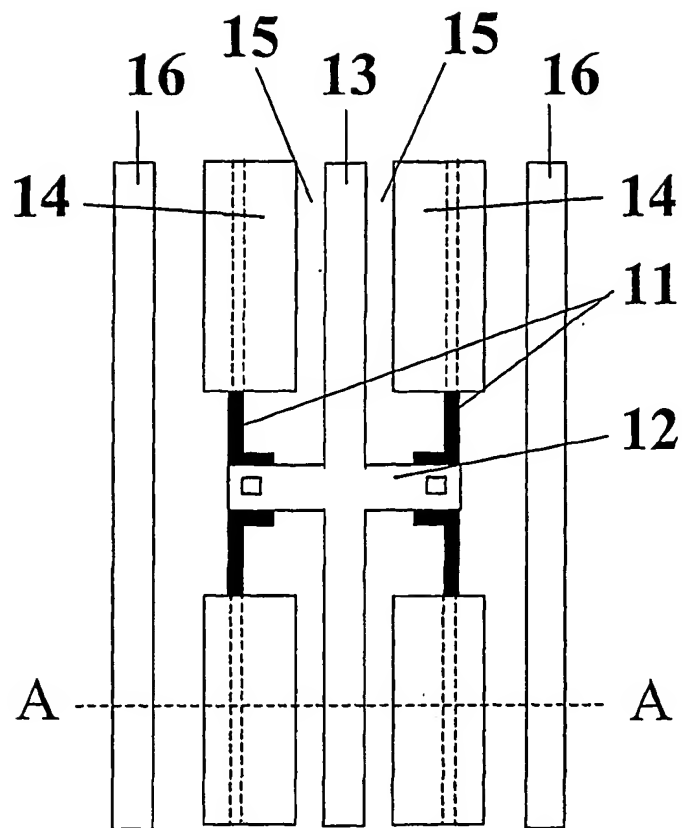


Fig. 3

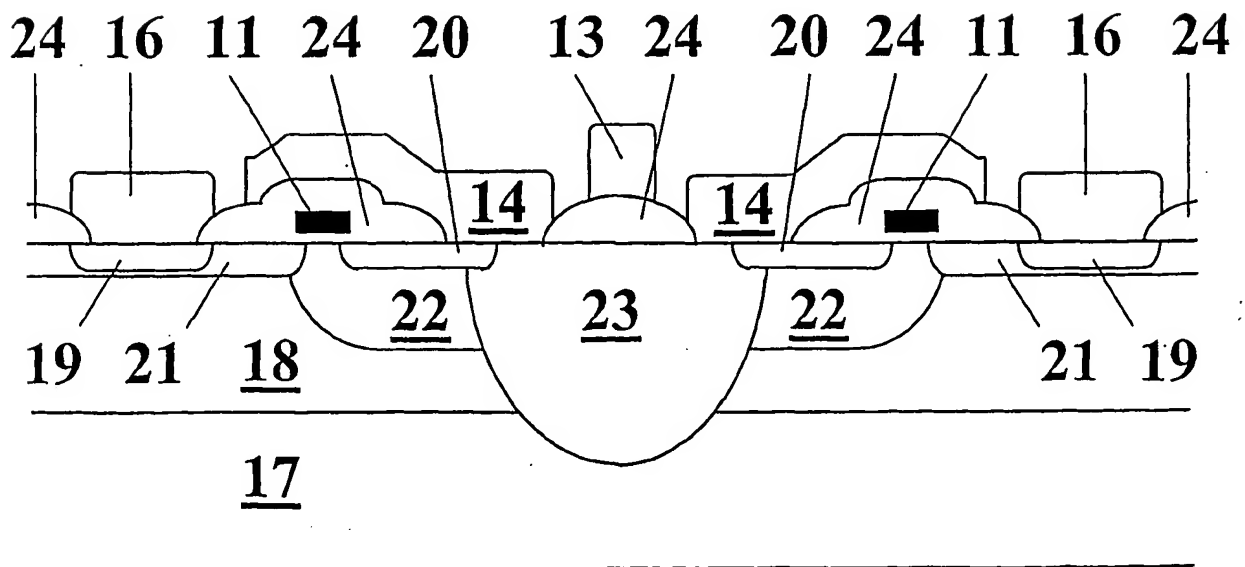


Fig. 4

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/00414

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01L 29/78, H01L 23/528

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5681761 A (MANJIN J. KIM), 28 October 1997 (28.10.97), column 3, line 49 - column 4, line 47  -- -----	1-2

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

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Date of the actual completion of the international search

6 June 2002

Date of mailing of the international search report

13-06-2002

Name and mailing address of the ISA/

Swedish Patent Office

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International application No.  
PCT/SE 02/00414

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